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maintenance and standardization of the detection sensitivity can be achieved, there was the problem that considerable time was required for adjustment in the event of alterations in the type of electronic equipment being manufactured.

5       With increases in the structural fineness and performance of components in recent years, the poor throughput of visual inspection has become increasingly prominent. There are therefore considerable expectations in regard to improvement of performance of machines that

10       perform image processing.

15       However, although the structural fineness and performance of electronic equipment devices such as liquid crystal panels, plasma or display panels and semiconductor wafers has considerably increased, these devices are often

20       formed with a large number of repeated patterns identical to a partial pattern. To detect defects in such repeated patterns, conventionally, processing was performed as follows.

25       Firstly, pattern erasure is performed as described below by performing the processing:

$$g_{out} = g_{in} - g(in + size) + offset$$

on all the pixels of the raw image, including the imaged repetition pattern, that are within the processing region, with the standard pitch of the repetition pattern.

Here,  $g_{out}$  is the density of the pixels of the image after

processing,  $g_{in}$  is the density of the pixels of the raw  
image,  $g_{(in+size)}$  is the density of a pixel separated by  
the standard pitch from the pixel chosen as the origin of  
the raw image, and offset is the density that is added as a  
5 reference density in the image after processing; in the case  
of 8-bit 256 gradations, this is usually the central 128  
gradations. This processing is called pattern erasure  
processing; the image obtained by this processing is called  
the background image or image after pattern erasure  
10 processing.

Secondly, pixels whose density differs considerably  
from the background density of the background image are  
detected as defects. This processing is called defect  
detection processing.

15 The description will now be continued with reference to  
Figure 5A and Figure 5B. Figure 5A shows the raw image  
prior to pattern erasure processing, in which an elongate  
pattern is repeated. Figure 5B shows the image after  
pattern erasure processing. The 21 pixels that are closest  
20 to the pattern pitch are taken as constituting the size in  
the expression given above for pattern erasure processing.  
Processing is performed in the range of processing region 50  
illustrated in Figure 5A.

Also, at the bottom of Figure 5A and Figure 5B, there  
25 are shown the density profiles 53 and 54 on the check lines



Thirdly, processing of the peripheral pattern cannot be performed normally.

These are now described in detail below.

The first problem does not arise if the pattern pitch is an integer at all locations. However, it is impossible for the pitch to be the same over the entire raw image. This is because, when image pickup is effected through a large number of lenses employed for image input, due to the effects of lens aberration, image pickup cannot be effected at exactly the same pitch in the center and periphery of the lenses. Also, it is difficult to make this an integer value with no error at all. Examples are the residual portions 58 and 59 of Figure 5B.

The second problem is a phenomenon that may occur due to comparison before and after. The white defect 56 in the middle of the processing region 50 of Figure 5A appears as defect portions 56 and 57 in Figure 5B which are of higher density and lower density than the background density. The distance between pixel 56 and pixel 57 is of course the size of the pattern erasure processing. It is therefore impossible to tell simply from an individual defect portion, whether the original defect was a white defect or a black defect.

The third problem, like the second problem is a phenomenon that may occur due to comparison before and after.

When pattern erasure processing is performed over the entire input image, as shown in Figure 6A and Figure 6B, a region 60 corresponding to the size of the pattern erasure processing on the right hand side of the region cannot be  
5 obtained as a result of normal processing. This is because there are no comparison pixels.

#### SUMMARY OF THE INVENTION

An object of the present invention is to solve the  
10 above problems and to provide a method of erasing repeated patterns in which inspection of defects in a repeated pattern can be performed without problems.

A method of erasing repeated patterns according to the present invention comprises, in a dark/light image obtained  
15 by image pickup of a subject of inspection, when identifying defects present in a repeated pattern in a subject of inspection, a step of detecting a plurality of density differences in which the density differences are found between reference pixels separated by values of a pre-  
20 determined reference size and sizes which are integral multiples thereof and a plurality of comparison pixels, a step of determining a specific density difference wherein the density difference that is closest to 0 or the mean density difference from a plurality of density differences  
25 is detected as specific density difference, and a pattern-

erased image generation step in which the specific density difference is applied to the reference density in the pattern-erasure image; by detecting the specific density differences using the density differences with respect to a plurality of comparison pixels, the problems mentioned above are eliminated and a repeated pattern can be suitably erased without using a complicated algorithm.

Also, a pattern defect inspection device according to the present invention comprises an image pickup element that picks up an image of an inspection subject and a processing device that detects pattern defects by storing and processing dark/light image data obtained by image pickup of the inspection subject wherein the processing device comprises: a portion for detecting a plurality of density differences in which the density differences are found between reference pixels separated by a pre-determined reference size and sizes which are integral multiples thereof and a plurality of comparison pixels; a specific density difference determining portion wherein the density difference that is closest to 0 from a plurality of density differences is detected, a pattern-erased image generation portion in which the specific density difference is applied to the reference density in the pattern-erasure image; and a defect detection portion; thus the repeated pattern can be

erased and pattern defects detected in a suitable way as described above.

Other and further objects, features and advantages of the invention will appear more fully from the following  
5 description.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a layout diagram of a pattern defect inspection device wherein an embodiment of a method of  
10 erasing repeated patterns according to the present invention is applied;

Figure 2 is a processing flow chart of a repeated pattern erasure method according to the above embodiment;

Figure 3 is a diagram of filter elements in this  
15 embodiment;

Figure 4A and Figure 4B are diagrams of images before and after processing in this embodiment;

Figure 5A and Figure 5B are diagrams of images before and after processing by a repeated pattern erasure method  
20 according to a prior art example; and

Figure 6A and Figure 6B are diagrams of images before and after processing illustrating a region which is incapable of being processed in the prior art example.

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#### DESCRIPTION OF PREFERRED EMBODIMENTS



An embodiment in which a repeated pattern erasure method and pattern defect inspection device according to the present invention are applied to inspection of an electrode wiring glass panel in a liquid crystal array panel is described below with reference to Figure 1 to Figure 4.

In Figure 1, which illustrates diagrammatically the construction of a pattern defect inspection device according to the present invention, the subject of inspection 1 is arranged in a prescribed position and is supplied with illumination by downward illumination 2, and an image thereof is picked up by an image pickup element comprising a CCD area sensor etc. The image data from the sensor pixels in image pickup element 3 is transferred, in one-to-one correspondence, to image memory 5 in a computer 4 constituting a processing device. The image data transferred into this image memory 5 is read to computer 4 and a processing program 6 is stored that performs prescribed processing. The image density is processed in 256 gradations, namely, 0 to 255.

Figure 2 shows the flow of processing of the method of detection of defects by repeated pattern erasure. In Figure 2, first of all, in image input step No. 1, the image data that is obtained from image pickup element 3 is stored in image memory 5 of computer 4. Next, in a plurality of density difference detection steps of step No. 2, the



reference density in the pattern erasure image. The reference density is determined in the same way as the offset described in the prior art example; in the case of 256 8-bit gradations of 0 to 255, the reference density will often be gradation 128.

Figure 4A is an image which has a repeated elongated pattern prior to pattern erasure processing and Figure 4B is the image after processing. Even if processing is performed on the entire input image area, the first to third problems of the prior art example are solved. White defect 20 and black defects 21, 22, 23, and 24 respectively appear in the image after processing as an independent white defect and independent black defects. Also, normal processing can be performed over the entire area of the image and the pattern can be reliably erased.

Although, in the description of the above embodiment, in the step of determining the specific density difference, the specific density difference that was closest to 0 was selected, depending on the circumstances, the mean value of a plurality of density differences could be selected as the specific density difference.

Since, with the method of erasing repeated patterns and pattern defect inspection device according to the present invention, there are provided a step of detecting a plurality of density differences in which the density

differences are found between reference pixels separated by the value of a reference size which was previously found as described above and values of integral multiples thereof and a plurality of comparison pixels, a step of determining a specific density difference wherein the density difference that is closest to 0 or the mean density difference is detected as specific density difference from a plurality of density differences, and a pattern-erased image generation step in which the specific density difference is applied to the reference image of the pattern-erasure image, the problems of the prior art are solved, and, without using a complicated algorithm, the repeated pattern can be suitably erased, making it possible to detect pattern defects.

Although the present invention has been fully described in connection with the preferred embodiment thereof, it is to be noted that various changes and modifications apparent to those skilled in the art are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.